



## Application Note

AN-75

copyright

April, 2026

web = [www.kh6htv.com](http://www.kh6htv.com) email = [kh6htv@arrl.net](mailto:kh6htv@arrl.net)

# Amateur Analog AM Television

Jim Andrews, KH6HTV

Today in 2026, a lot of the world's electronic communications are now done with some form or another of digital modulation. Yet there is still residual nostalgia for some of the old, original, analog modulation schemes. Analog, NTSC, amplitude modulation of television images is one of those. The purpose of this application note is to discuss AM-TV and what equipment is still available for amateur radio experimenters wanting to still keep this mode alive. Ref. [1] covers both AM, FM and digital TV.

**TV HISTORY:** The transmission of “live” video images via the radio air waves is now celebrating it's 100<sup>th</sup> anniversary. Television is an old RF communications technology dating back to the 1920s. Here is a brief early time line of those events.

- 1925 – QST reports on TV experiments using mechanical scanning
- 1926 – John Blair in Scotland, demos 1st working TV using mechanical scanning
- 1927 – Philo Farnsworth, 1st patent for all electronic scanned TV system
- 1929 – 1st TV broadcast, BBC, London
- 1939 – NBS 1st live USA TV broadcast, New York City
- 1940 – 1st ham TV 2 way QSO, W2USA & W2DKJ in New York City, 56 & 112MHz
- 1941 - FCC issues NTSC standard for TV

**ATV HISTORY:** Amateur TeleVision, (ATV) started to become popular among amateur radio experimenters in the 1960s and 70s. Some of the earliest ATV transmitters were modified, surplus, old taxi cab, UHF, FM voice transmitters. They were from companies such as Motorola, GE, RCA, etc. These were crystal controlled with only one 1 or 2 frequencies. Typically hams would tune them down to the 70cm ham band and do grid modulation with video of the final RF amplifier tube. Due to the narrow bandwidth of these transmitters, they were only capable of black & white video.

I myself had one such rig. It was a Motorola T-44 which I grid modulated to get a whooping 100 Watts PEP TV signal. It was actually the highest power TV transmitter I ever had in my life ! I had to put a massive blower on it to cool it. They were never designed for the 100% duty cycle we typically run with ATV transmissions. So as a result it ended up overheating and finally actually melted the 2C39 final tube ! It got so hot in imploded !

The first magazine devoted to ATV appeared in the early 1960s. It was called the "ATV EXPERIMENTER", by Mel Dunbrack ,WIBHD. It lasted a couple of years. Then in the late 60s the "A5 Magazine" appeared. It had a long life run until 1985 and saw several different editors. In the late 80s, it was followed by the "Amateur Television Quarterly" which run up to 2018, again with several editors. Starting in 2018, Jim Andrews, KH6HTV, started publishing an electronic (via e-mail) free ATV magazine. It was first called "Boulder TV Repeater's Repeater" and later was renamed "ATV Journal'.



Fig. 1 Tom, W6ORG, and his model TC-1 70cm AM-TV Transmitter introduced at Dayton in 1977. The "work-horse" of ATV for many years.

By the 1970s, we started to see transistorized AM-TV transmitters appearing for the ATV market. Most of the suppliers were ATV hams starting small businesses. By the late 70s, one supplier arose which soon dominated the ATV transmitter market for many years to come. It was W6ORG, Tom O'Hara's Mom&Pop company called P.C. Electronics. Tom eventually retired in 2014 and closed down P.C. Electronics with the advent on digital TV. Over the years Tom reported selling many thousands of his TV transmitters. For the next 30+ years, if you visited an ATVers ham shack or ATV repeater site, you would have found Tom's gear being the heart of the operation. Today (2026), Tom's gear can still be found occasionally at ham radio swapfests and on line at E-Bay. Tom contributed articles to the ATV magazines. He was also for many years the author of the chapter on ATV in the ARRL Handbook. Tom needs to be honored as the father (grand-father) of USA ATV. Although Tom is now retired, his web site is still up and is worth a visit. [Www.hamtv.com](http://www.hamtv.com)

**TV BASICS:** The basic concept of capturing a "live" video image consists of grabbing a sequence of still images at a fast enough rate that the human eye perceives them to be "live". In the motion picture industry, they found that a frame rate of 24 fps (frames per second) was sufficient. For TV, a frame rate of 30 fps (25 fps in Europe) is used. The historical reason for 30 fps rather than 24 was the presence of 60 Hz "hum" in the early day vacuum tube circuits. Using  $1/2 * 60$  Hz minimized the hum interference

in video images. 50 Hz AC is used in Europe and most of the rest of the world, hence the 25 fps for their TV systems.

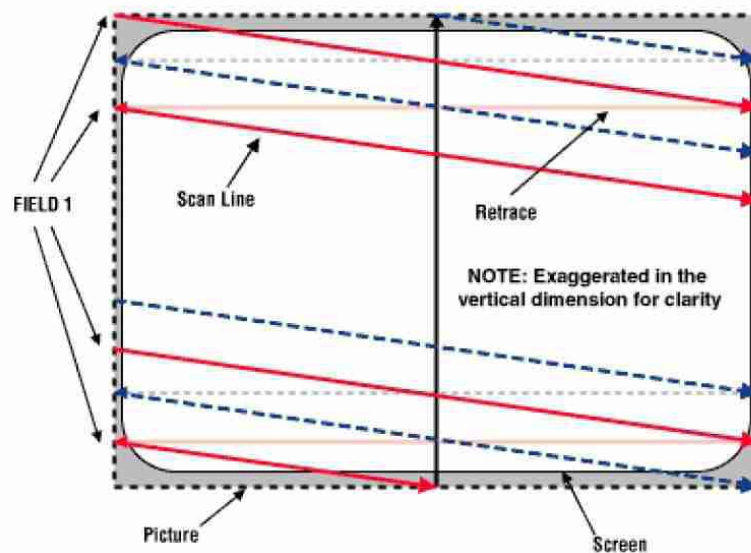


Fig. 2 Scanning on a CRT to display a TV image.

Until fairly recently, all of our TV receivers used a cathode ray tube (CRT) as the display device. A CRT presents a single spot (or pixel) on its screen at any one time. The persistence in the phosphor made that spot glow for some time after it was illuminated by the electron beam. Thus, to present a complete image the electron beam needed to be swept (or scanned) sequentially across the CRT phosphor screen, from left to right and from top to bottom. To maintain synchronization between the initial image scanning camera and the display CRT a set of horizontal and vertical synchronizing pulses were required to maintain the proper timing.

During the early development of TV in the 1930s, many experiments were run, using the available technology of the time, and a set of TV standards were developed for scan rate, lines, etc. This was formulated by 1941, by the TV R&D people and the FCC into what is called the NTSC (National Television System Committee) standard. It resulted in the standard composite video signal with 525 horizontal scan lines at a 30 Hz frame rate. A CRT display would first sweep from left to right, then rapidly reset back to the left side of the screen and index down a line. See Fig. 2. When the scan finally reached the bottom of the screen, it would then be reset vertically to the top of the screen and a new frame would commence. These horizontal scan lines were interlaced with only 480 of them actually being visible. Hence the term 480 i. The remainder were masked during the vertical retrace time interval.

The base-band, composite video signal is standardized as a 1 V<sub>ptp</sub> signal into 75 Ohms. See Fig. 2. The various levels were measured in IRE (Institute of Radio Engineers) units, where 140 IRE = 1 Volt. The active video information occupied 100 IRE units and it could assume any value depending upon the gray level of the pixels. The horizontal and vertical sync pulses occupied 40 IRE units. The highest level was white.

The lowest was the tip of the sync pulses. The vertical sync occurs at 29.97 Hz. The horizontal sync at 15.748 Hz. There are 525 lines per frame with 262.5 lines per field. Two interlaced fields make up a single frame. Thus for 480 i video we have 640 x 480 pixels.

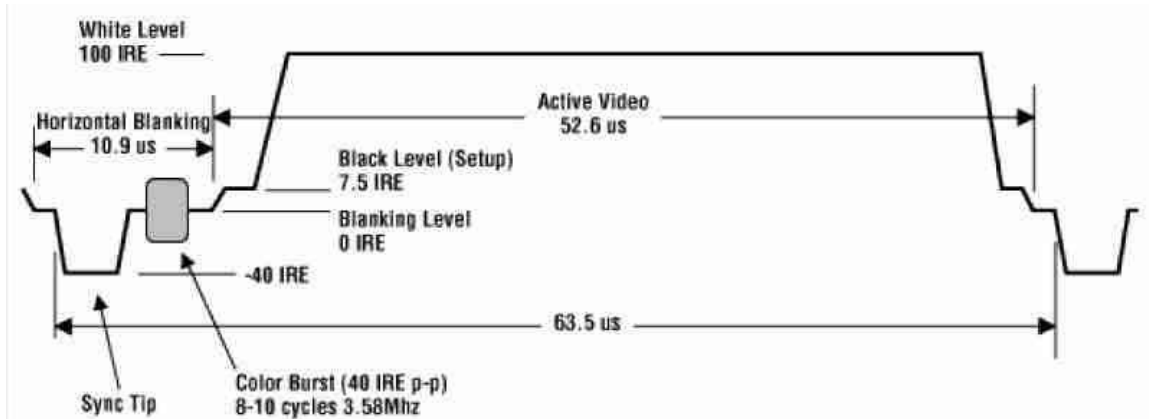


Fig. 3 Composite, base-band, Video Signal. 1 Volt p-t-p into 75 Ohms. 140 IRE units = 1 Volt. One horizontal line shown.

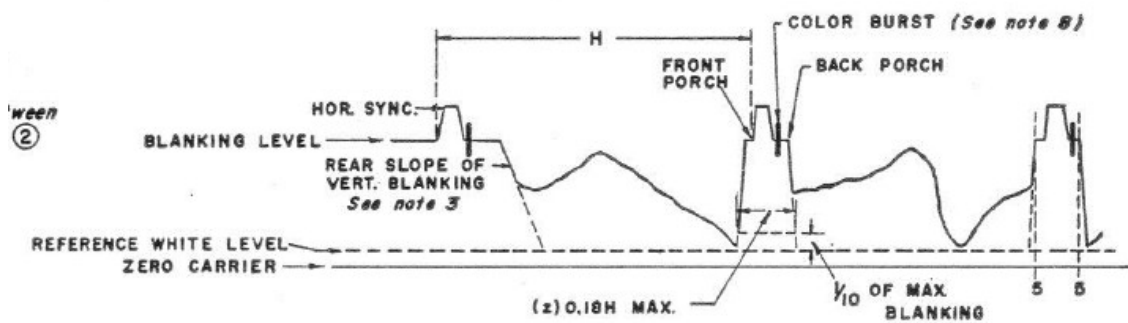


Fig. 4 RF envelope of an NTSC TV transmitter. This drawing is from FCC's NTSC Signal Specifications, Dec. 17, 1953.

Fig. 4 shows the RF envelope of a AM modulated, TV transmitter when modulated by the standard composite video signal. Note that the sync pulses on the baseband video signal are negative going. After modulation of the transmitter, the sync pulses are inverted and are the strongest portion of the RF signal. The standard levels are: Sync = 100% Blanking level = 75% and White level = 12.5 to 15%. For amateur TV transmitters which include the 4.5 MHz sound-sub carrier mixed with the video signal, the white level should never be set lower than the 15% minimum.

In 1953, NTSC added color to the basic TV signal. The color system adopted was designed to be backwardly compatible with the original black & white TV. This was done by adding a color sub-carrier (CSC) of 3.58 MHz with independent sidebands carrying the color information. The color burst shown in Fig. 3 was used to synchronize the 3.58 MHz color local oscillator in the receiver. Fig 5 shows a composite video signal carrying color information for a color bar test pattern.

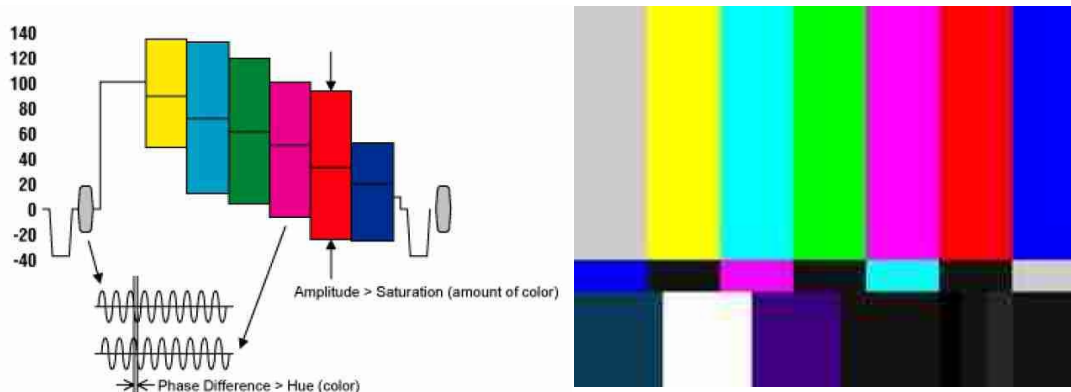


Fig. 5 Composite video signal with color bars & the resultant image on a video monitor.

**ANALOG TV MODULATIONS:** For analog TV, there are basically three modes in use. They are AM-TV, VUSB-TV and FM-TV. We will not discuss FM-TV in this application note. The NTSC standards were developed in the 1930s and early 40s. At that point in time, the method used for voice modulation of radio transmitters was AM or amplitude modulation. Thus, it was natural that AM also be used for their video TV experiments. The early engineers did however recognize the redundancy in having two identical sidebands in AM and found they could conserve bandwidth by filtering off a portion of the lower sideband, hence Vestigial Upper Side-Band, ( VUSB-TV). [2] This became etched in stone with the FCC adoption of the NTSC standard in 1941. It remained in place for the next 68 years until 2009 when the USA switched over to DTV.

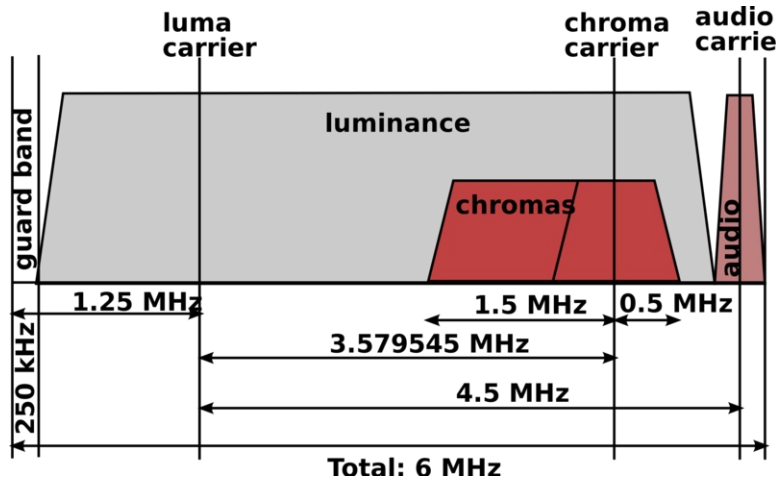


Fig. 6 The rf spectrum of an analog NTSC - TV signal.

The NTSC, base-band, composite video signal's spectrum extended from the low 60 Hz sync rate of the vertical pulses up to an upper luminance (i.e. B&W) bandwidth of 4.2 MHz. The color (or chroma) information requires less bandwidth. It is carried via a 3.58 MHz color sub-carrier as independent upper and lower sidebands. When broadcast by the NTSC system, the composite, 4.2 MHz bandwidth video signal is first **AM**

modulated onto an rf carrier. This would result in a double sideband rf signal occupying at least 8.4 MHz of bandwidth. To conserve bandwidth, the original NTSC standards called for filtering off all but 750 kHz of the lower sideband. The result is called a Vestigial Sideband (VSB) signal - or VUSB for Vestigial Upper Side-Band. The rf video carrier was placed 1.25 MHz up from the lower channel edge. Audio was then added using a separate FM transmitter, placed 4.5 MHz above the video carrier frequency. Fig. 6 shows the resultant spectrum. It occupies a 6 MHz wide TV channel with a 250 kHz guard band.

Commercial broadcast TV stations typically used two transmitters. The Visual transmitter was AM modulated by the video signal and used a sharp cut-off, RF band-pass filter to give VUSB-TV. A second, Aural transmitter was used for audio and it was an FM transmitter with its frequency set 4.5 MHz above the visual transmitter. Most all early amateur TV transmitters simply used AM-TV without filtering off the lower sideband. Fig. 7 below compares the two resultant spectrums.

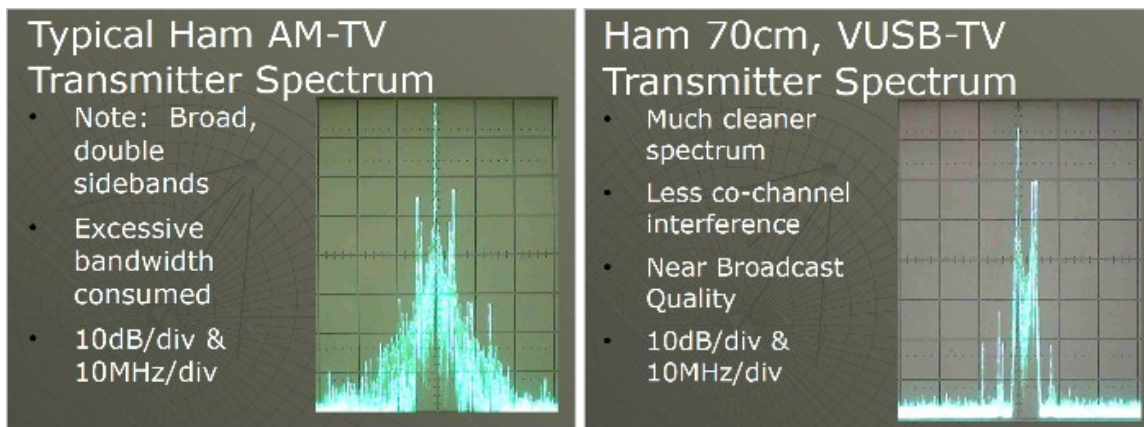
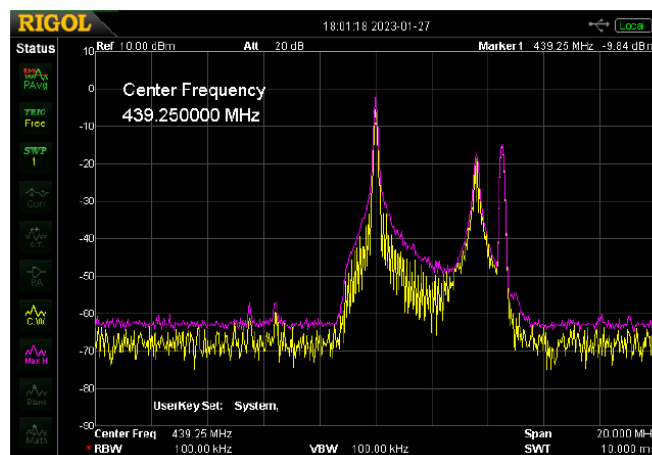


Fig. 7 NTSC Television Transmitters' RF spectrums. AM-TV (left) & VUSB-TV (right)



NTSC Modulator Output

Fig. 8 Close up with more details of a VUSB-TV rf spectrum. The input video signal was a color bar test pattern (see Fig. 5). RF center frequency is Ch 60, 439.25 MHz. Vertical scale is 10dB/div. Horizontal scale is 2 MHz/div. Yellow trace is "live" single sweep. Magenta trace is analyzer in peak hold mode. The transmitter's video carrier is on the center at 439.25 MHz. The color sub-carrier is +3.58 MHz to the right of the video carrier. The sound sub-carrier is +4.5 MHz to the right of the video carrier.

## P5 - TV SIGNAL QUALITY REPORTING [3]

For analog TV reception, there are two types of major defects noticeable in the displayed pictures. A poor signal to noise ratio introduces what is most often described as "snow" in the picture, as seen below in Fig. 9. The other defect often seen is an additional weaker image seen displayed to the right of the correct image. This is due to "multi-path". It is the presence of a second rf wave arriving later in time from the direct path rf wave.

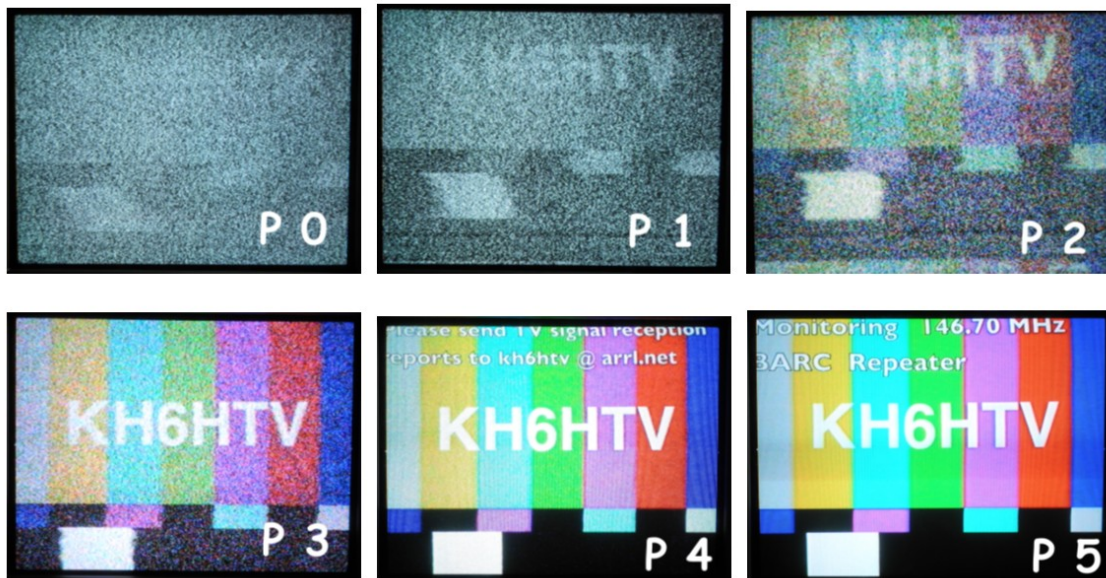


Fig. 9 ATV system of reporting Picture Quality

In HF radio we report signal reception using the RST method. R = Readability, S = Signal Strength and T = Tone (only used for CW). Thus a 5-9 report means perfectly readable with an S-9 on the S meter. For ATV we use a similar method for reporting the quality of the received image. We called it the P rating, i.e. Picture rating. Fig. 9 shows examples of various weak analog ATV signals and their respective P rating.

- P0 Extremely weak signal. At the threshold of the receiver noise. Can only detect the presence of possible sync. No useable image.
- P1 Very weak signal. Can detect presence of video buried in the noise. Mostly snow. Receiver often times has difficulty sync locking. Only very large block

letters are barely readable, such as in a camera view of only the call sign on a stationary, automobile license plate. OK for DX reporting only.

- P2 Weak signal. Lot of snow present in image. Black and White only. No audio. Can detect presence of people in the image and movement. Not a useable picture for routine, pleasurable viewing. Note: some excellent receivers might show color with a P2 signal. Then instead of white "snow", you will experience a shower of colorful confetti !
- P3 Moderate signal. Still has snow present in image. Color lock. Audio is present, but noisy. Acceptable picture for people living in very rural areas watching broadcast TV.
- P4 Strong signal. Very good color and audio. No snow or confetti. Some defects noted in picture quality. Almost full quieting on the FM audio.
- P4.5 Strong signal. Only a very few, minor picture defects. A border line P5.
- P5 Very strong signal. Perfect, noise-free, picture and audio.

Fig. 10 shows for VUSB ( or AM ) TV transmissions, to obtain a P5 picture requires an RF signal to noise ratio of  $S/N > 40$  dB. For each P unit from P0 to P4, there is an increase in signal strength of 6 dB, i.e. the same definition as used for S units.

For NTSC, AM-TV, a very strong signal of at least -60dBm is required at the receiver's antenna input to give a perfect P5 picture.

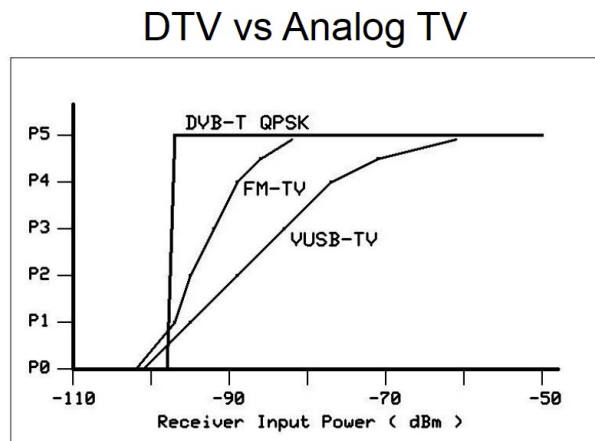


Fig. 10 P units vs. Received Signal Strength

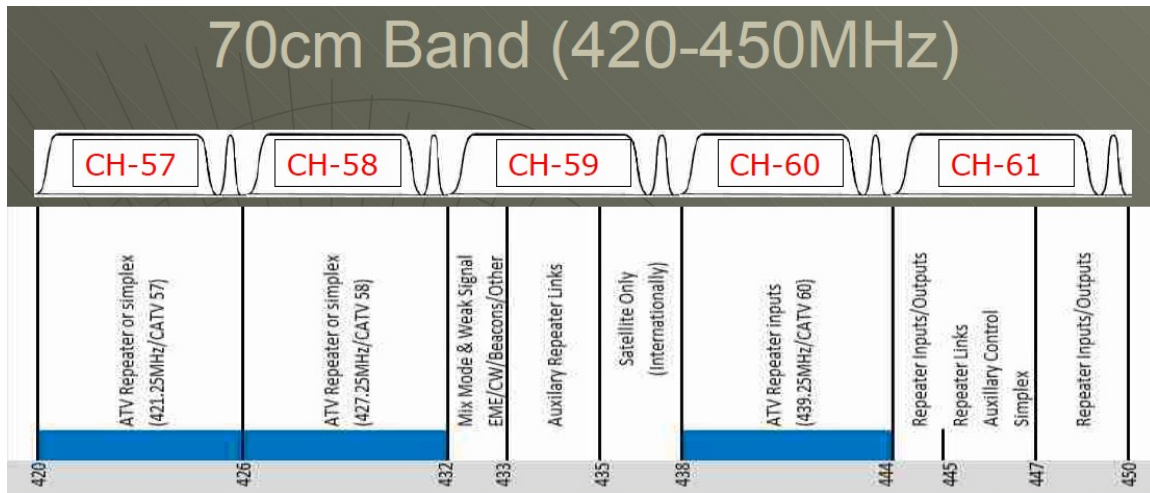


Fig. 11 ATV in the 70cm band -- 5 TV Channels

**ATV BANDS:** The FCC has allowed radio amateurs to transmit live TV pictures almost since the birth of TV. However, due to the extremely wide band-width required, we are restricted to doing it on the 70 cm (420-450 MHz) band or all higher frequency bands. [4] The original, analog, NTSC, TV transmissions required a 6 MHz wide channel. Modern day, commercial broadcast TV uses digital transmission, but still uses the same 6 MHz channels for each transmitter. All of our HF bands put together would not give us 6 MHz. We have to move up to the UHF region before we find enough bandwidth available to support TV. This means the first amateur band available for TV is our 70 cm band. It is 30 MHz wide and could potentially support up to five, 6 MHz, TV channels. See Fig. 11. Our 70cm band is actually just below the commercial broadcast TV, UHF band which starts at 470 MHz. As such, the rf propagation conditions are very similar. Note in Fig. 11 the designation of channel numbers 57 through 61. USA cable TV uses all of the spectrum from 54 MHz (Ch. 2) up to about 1 GHz, divided into adjacent 6 MHz channels. It turns out that CATV channels 57 through 61 actually land directly in the amateur 70cm band.

This is fortunate, in that a 70 cm, analog, ATV transmitter's signal can be received directly on a home TV receiver. During the transition from analog to digital, the FCC mandated that all TV receivers sold in the USA were required to include an NTSC analog TV receive capability for both the VHF/UHF broadcast bands and also cable TV frequencies. This FCC requirement however, “sun-set” in 2017. So, today, if you purchase a modern digital TV receiver, it may, or may not, also include the capability of receiving the old, analog NTSC signals. If yours does not, then you will need to purchase an additional set-top box receiver. The set-top box would appear essentially the same as those supplied by the cable or satellite TV company. Simply connect an antenna to it's ANT port and an HDMI cable from the A/V output to a separate video monitor.

The ARRL band plan for the 70cm band calls for Ch 58 to be used for simplex TV while Ch 60 and Ch 57 are to be used as the input and output channels for a TV repeater. The use of the other channels for TV is not recommended due to likely RFI to FM voice

repeaters on Ch 61 and weak signal SSB/CW and satellites on Ch 59. It should be noted that not all regions of the USA adhere to the ARRL band plan for ATV. Some regions use non standard frequencies. The most common being 426.25 MHz and 434 MHz for analog ATV. Depending upon your particular TV receiver, it may, or may not work on 426 or 434 when tuned to Chs 58 or 59.

The 70 cm band is by far and away the most popular and most useful of all the amateur bands for ATV. It has the combination of good propagation characteristics, most available equipment, reasonable size antennas, etc. All of the higher frequency amateur bands can also be used for ATV. As one goes higher in frequency, these microwave bands become more useful for point-to-point TV links, rather than wide-area TV broadcasting. The next most popular band after 70 cms is the 23 cm band (1240 - 1300 MHz). With 60 MHz available, it could potentially support up to ten, 6 MHz TV channels. In most areas, it is a fairly quiet band with much fewer users. The main issue for some large metro areas is the presence of government radars within the 23 cm band. They are primary there and amateur usage is secondary and we are not allowed to cause RFI to these radars.

## ATV TRANSMITTERS:

In the past, most all of the analog TV transmitters were for the 70cm band, with some also built for the 33cm and 23cm bands. Fig. 12 shows one such typical transmitter from that era. It was the P.C. Electronics model TC70-20. It was actually not just a 20 watt transmitter, but a Transceiver. It also included a varactor tunable receiving down-converter from the 70cm band down to channel 3 as an IF.



Fig. 12 Typical ATV AM transmitter

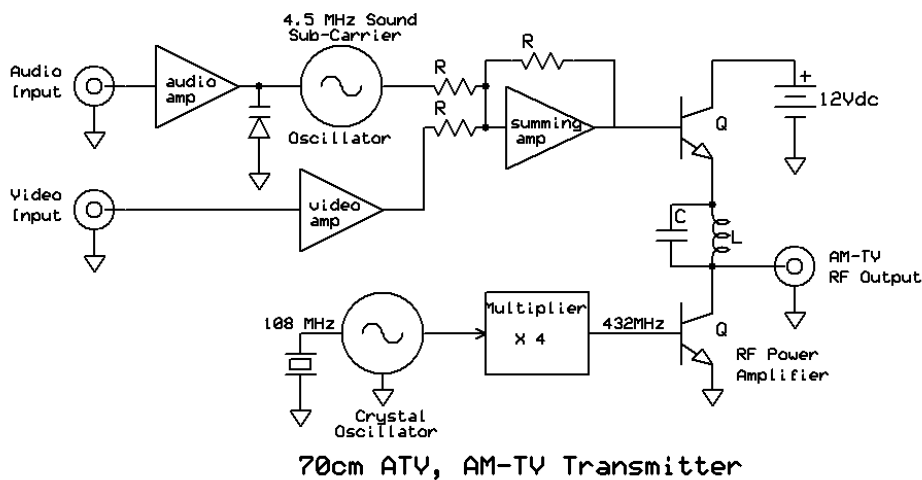


Fig. 13 Block Diagram of early days amateur AM-TV transmitter

Fig. 13 above shows the basic block diagram of how the earlier amateur AM-TV transmitters were built, including those from P.C. Electronics. They were all crystal controlled with typically only 1 or 2 channel capability. This does cause an issue now here in 2026. If you do get your hands on an old transmitter and it is not on your desired frequency, you will experience difficulty getting a new crystal for the correct frequency. Most all of the old line crystal companies, such as International Crystal have gone out of business. There are still some crystal companies who will accept orders for custom frequency crystals, but be prepared to pay an “arm and leg” for one ! There however, is a modern day IC solution for this. The IC is called a “Programmable Crystal Oscillator” or PXO for short. For details, see my app. Note, AN-56. [5] It includes details on how to build a simple circuit using a PXO in the old P.C. Electronics transmitters.

The Fig. 13 block diagram is the basics. One first created a 4.5 MHz sound sub-carrier (SSC) with a varactor tuned oscillator, FM modulated by the audio signal. This 4.5 MHz SSC was then mixed with the composite video signal in a summing video operational amplifier circuit. This combined A/V signal was then used to AM modulate the final amplifier in the transmitter. In the very early days of ATV, grid modulation of the vacuum tube final amplifier was used. With transistor transmitters, the AM modulation was applied to the collector of the final rf power transistor. In some transmitters, they might have then followed with a separate linear higher powered amplifier. But it had to be linear, not a class C amplifier.

**VUSB-TV Modulators:** It was possible for amateurs to have good quality, analog TV transmitters which adhered to the FCC, 6 MHz bandwidth limits, using VUSB. Simply adding to the output of an AM-TV transmitter, a 6 MHz wide, band-pass filter with steep skirts will accomplish this.[6] Unfortunately, there are not many suppliers of such filters and they are expensive, thus most ATV hams have ignored this solution.

Another VUSB approach used prior to the digital transition was to use the analog TV modulators previously used in the cable TV industry for their head-end installations. They created a very pure, spectrally clean VUSB-TV signal at the low 1 mW (0dBm) level. One would then amplify it with an rf linear power amplifier to the watt level. See Fig. 14 below. Fig. 7 shown previously is the spectrum from such a TV transmitter. It's spectrum is much cleaner compared to the AM-TV transmitter in Fig. 7.

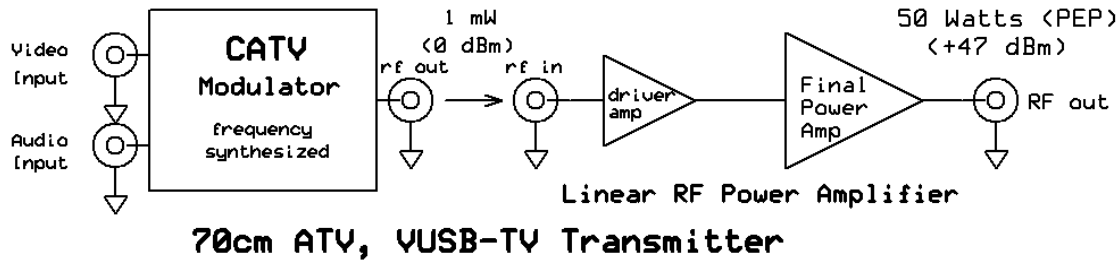


Fig. 14 Block Diagram for a VUSB-TV transmitter using an analog CATV modulator.

Again, the amplifiers following the modulator absolutely must be linear. No class C, FM amplifiers allowed. Also the linearity requirements are even more strict if the signal to be amplified is VUSB vs. AM. Any non-linearities in the amplifier chain will result in the re-creation of signals reappearing on the undesired lower side-band. Thus defeating the whole purpose of using VUSB. Some of them can be seen in Fig. 7, particularly in the presence of low level CSC & SSB at -3.58 and -4.5 MHz from the video carrier.

**CATV MODULATORS:** These must still be considered absolutely the first choice if wanting to build an NTSC analog TV transmitter. These CATV modulators, Fig. 15, most all came in what was called the mini-mod format to be plugged into a special rack side-by-side. Many units racked up side by side at the CATV head-end might create 100 or more simultaneous, adjacent TV channels for the cable TV system. They required +5V and +12Vdc power. There were two versions available. The lowest cost at about \$110 was a fixed frequency unit and had to be ordered by the desired CATV channel number. Also available were frequency synthesized units which covered all CATV channels, plus broadcast TV channels. They typically sold for about \$225, with stereo versions



Fig. 15 CATV Modulator

selling for about \$350. They were previously made by several companies, including; MACOM, Drake, Holland, Pico-Macom, Blonder-Tongue, etc. Unfortunately, now in 2026 with the transition to digital TV, these analog CATV modulators are now considered obsolete. They can still be found, but only occasionally on E-Bay. I have found however (2026), one company left still offering them for sale. It is the Toner Cable Equipment company. Their web site is: [www.tonercable.com](http://www.tonercable.com) They are still offering their single channel modulators (model TMM-45+) for \$105 and the frequency agile modulator (model TAMM-860 ) for \$145.

It should be noted that these CATV modulators will only work on standard NTSC TV channel frequencies. Thus for non-standard ATV frequencies, such as 426 or 434 MHz, they will not work.

**Toner Model TAMM-860:** 2026 tests were run on this particular CATV modulator. It was found to cover 54 to 860 MHz ( ch 2 - 135 ) and included the amateur 70cm band with cable channels 57-61. The max. PEP rf power output was -2dBm measured on the sync tips. It was adjustable over a 25dB range. The 2ed harmonic was well suppressed at -62dBc. The 4.5 MHz SSC level is selectable at either -15dBc or -20dBc. I calibrated it to set the deviation at 25 kHz. On the lower side-band, the SCC was suppressed at -55dBc. . The video and audio levels are adjustable. The upper side-band video frequency response was measured and found to be very flat up to +4.2 MHz. It then had a smooth sharp roll-off -3dB down at +4.9 MHz, -10dB at +5.4 MHz, -20dB at +5.7 MHz. On the lower side-band the vestigial filter worked well. -2dB down at -0.5 MHz, -10dB at -1.1 MHz and -20dB at -1.3 MHz. The audio frequency response was measured using as a standard receiver a Blonder-Tongue model MIDM-806C CATV demodulator. The audio response was found to be quite flat with -3dB band-width extending from 60 Hz to 18 kHz. Requires +5Vdc and +12Vdc power.

**AM-TV Modulators:** OK, so what other options do we have in 2026 if we can't find CATV modulators ? Fortunately, China is addressing the forgotten analog TV market with a few offerings. As is the case with most things these days from China, they come from totally unknown manufacturers, with no brand names on their products. Plus, they might be here today and gone tomorrow ? Also, they either come with no advertised specs and in many case mis-leading or false specs. Best to rely upon the advice of other hams before purchasing. I have made numerous Google searches of the internet and have found a few suitable products, which I or other hams have evaluated.

### China Model HDM65:

A 2026 google search turns up this analog modulator offered by several different distributors, including Amazon. No brand name, simply the model # HDM65. Currently selling in the \$30-\$50 price range. I did purchase one recently for evaluation. I did find that it is suitable for use as a 70cm, ATV modulator. Here are the results of my evaluation.



Fig. 16 HDM65 AM-TV Modulator

**Packaging:** It is an all metal enclosure of X"xXxX" with additional blue plastic mounting brackets. It is powered via a 115Vac power cord. 2 digit LED display. Adjustable gain controls for RF level, Video and Audio. Four programming push buttons. Loop-thru, type F rf connectors. Dual A/V inputs of HDMI (digital) and RCA composite video and stereo audio.

**Frequency Range:** Sound sub carrier frequency adjustable to 4.5, 5.5, 6.0 & 6.5 MHz. The sound sub-carrier can not be disabled. Video frequency range is 47 to 888 MHz. The video frequency can only be set to standard NTSC or PAL broadcast frequencies. Thus for amateur use it is only useable on cable channels 57, 58, 59, 60 & 61 in the 70cm band. It can not be set to non-standard frequencies such as 426.25 nor 434 MHz.

**RF Output:** The max. rf output power was measured to be -10dBm, pep, peak sync. It is adjustable over a 25dB range. The 2ed harmonic of the video carrier was suppressed by -55 dB. The 4.5 MHz SSC level was fixed at -18dBc and was present equally on both the upper and lower side-band. I calibrated it by setting the deviation at 25 kHz.

**Frequency Response:** The video and audio levels are adjustable. The upper/lower side-band video frequency response was measured and found to have a smooth roll-off over the standard 4.2 MHz video pass-band. It was -1dB down at 2.5 MHz, -2dB at 3.2 MHz and -3dB at 4.6 MHz. It then dipped to -20dB down at 7 MHz, but then fully recovered again beyond 10 MHz. The audio frequency response was measured using as a standard receiver a Blonder-Tongue model MIDM-806C CATV demodulator. The audio response was found to not be flat, but peaked at 100 Hz with -3dB band-width extending from 33 Hz to only 3 kHz. It was -6dB down at 8 kHz.

**HDM65 CONCLUSIONS:** The HDM65 is a good, low cost choice for a 70cm AM-TV modulator.

---

### HLLY TVX-50:

In 2020, Burt, N7CS, discovered AM-TV transmitters from China under the brand HLLY. It was reported on in our ATV Journal newsletter, issue #45. The model TVX-50 was evaluated and found to be suitable for use as a 70cm or 33cm AM-TV modulator. A google search shows that it is still available on E-Bay in 2026. Current price is about \$110 plus shipping.



Fig. 17 HLLY AM-TV Modulator

**Packaging:** The TVX-50M transmitter is nicely packaged in an all metal enclosure of 5.4" x 3.8" x 1". It has a 2 line, mono-chrome LCD display of 2.5" x 0.6". The display only displays the video carrier frequency and the sound sub carrier frequency, both of which are adjustable. The only controls are a on/off power toggle switch and 3 programming push buttons labeled Confirm Shift and Set. Mono audio and video inputs are RCA jacks. RF output is a BNC. DC power is via a standard DC jack. 12Vdc power, center pin = +. The antenna provided is a nice, adjustable angle, telescoping BNC antenna.

**DC Power:** The dc power requirements is nominally +12 Volts. The current draw was 180mA. RF output started dropping at +11 Vdc. The unit worked the same at +13.8Vdc as it did at +12Vdc.

**Frequency Range:** I found that I could adjust the sound sub carrier frequency to 4.5, 5.5, 6.0 & 6.5 MHz.. The video carrier frequency could be adjusted from 28 to 990 MHz in 250 kHz steps, but not in the advertised 100 kHz steps. Thus the tuning range was wider than advertised, but the tuning steps were less. The sound sub-carrier can not be disabled.

**RF Output:** The RF output power was advertised to be 50mW (+17dBm). I measured +15dBm (PEP on the sync tips), i.e. about 30 mW. The rf output level is not adjustable.

**Spurious & Harmonics:** I set the unit to 439.25 MHz with a 4.5 MHz SSC and then examined the spurs & harmonics. The video carrier was +15dBm, The 4.5 MHz SSC on either side was -17dBc (i.e. -17dB below the level of the video carrier frequency ) The second harmonics of the SSC were -43dBc. The advertised spec. for harmonics & spurious was greater than -50dBc. They missed it by a long shot. The 2ed harmonic was -26dBc and the third was -17dBc. There were several spurs noted at about -35dBc. They were at 18, 218, 660 & 1098 MHz.

**Video & Audio Performance:** The video performance was good. Tested with a multi-burst signal, the frequency response was flat up to 3.58 MHz and down 50% at 4.2 MHz. Color reproduction was very good. The video gain was found to be low. Sync was -33 IRE when it should have been -40. The white level was +92 IRE when it should have been 100. I did not test the audio FM deviation, but the audio sounded fine. I did measure the audio frequency response and it did match the spec. of being -3dB down at 50 Hz and 15kHz.

### **HLLY Conclusions:**

1. The key advantage I see in the HLLY unit is it's ability to be tuned to the non-standard 70cm frequencies, some ATV groups in the USA are using. These include: 426.25 MHz and 434.00 MHz. Most other modulators will not tune to these frequencies. The HILLY will. It will also go up to 990 MHz, thus making it useful for the amateur 33cm band.
2. For driving an rf linear power amplifier, it is desirable to have an adjustable rf level from the modulator. It is not possible with the HLLY. Fixed rf output. You will need to use external, attenuators to set the proper drive level for an amplifier.
3. HLLY also offers on E-Bay their model TVX-02S which they claim puts out **2 Watts**. This has not been evaluated, but might be quite useful as a stand alone ATV transmitter. It's current (2026) price is \$220.

## Ch 3 – 4 MODULATOR:

Another possible approach for generating an ATV analog signal is to use a very low cost A/V to RF modulator module. It is the least desirable. You will find lots of these available on the internet from Amazon, E-Bay, etc. Typical cost is about \$20 for composite video input or \$30 for HDMI input. These are fixed frequency with typically a switch to set them to either broadcast TV channel 3 or 4. (61.25 or 67.25 MHz).



Fig. 18 Ch 3 / 4 TV Modulator

### Conclusions:

1. The modulation mode is AM-TV. It does include a 4.5 MHz FM stereo sound-carrier.
2. The main disadvantage of this modulator is the fact that it only works on either channel 3 or 4. Thus it must be considered to be an IF modulator. To work on any legal amateur band, it's IF output must be up-converted using a local oscillator (LO) and mixer.
3. There are no adjustments on this unit, except for the Ch 3 or 4 selector switch.
4. The max. rf output power is fixed at -20dBm peak sync. The SSC level is fixed at -15dBc on both upper and lower side-band. It has extremely strong harmonic content on the rf output with the video carrier appearing at all odd harmonics.  $3x = -10\text{dBc}$ ,  $5x = -15\text{dBc}$ ,  $7x = -20\text{dB}$ , etc.

## LINEAR AMPLIFIERS:

To assemble an analog AM (or VUSB) ATV transmitter using the modulator scheme shown in previous Fig. 12, requires an additional RF power amplifier to boost the signal level from the milli-watt level to several watts of rf power.

The requirements for rf power amplifiers for ATV depend upon the modulation mode used. However, there is one common requirement. The amplifier must be rated for 100% duty cycle, continuous service. While typical amateur voice communications are mostly receiving and intermittent transmitting, a typical ATV transmission can run for many minutes, to hours or days in length. Another common requirement is that it should be broad-band, preferably covering the entire ham band. With ATV, we tend to move around the whole band with our 6 MHz wide ATV channels. Tuned amplifiers tend to be too narrow-band for ATV service.

For AM-TV, or VUSB-TV, a linear amplifier is required. If the AM-TV operator is not concerned about chewing up spectrum, they often push their power amplifiers to their limits. Doing this does cause severe compression of the sync pulses, which is actually

self-defeating as it impairs the receiver's ability to lock onto a weak TV signal. This was often overcome in the AM-TV modulator stage by adding a sync stretcher circuit to boost the amplitude of the modulating sync pulses. This technique was used in the older P.C. Electronics AM-TV transmitters.

Driving an amplifier too hard and also the inherent non-linearity's in the amplifier itself result in creating distortion products which appear outside of the allocated TV channel. For VUSB-TV, this becomes very evident by the re-appearance of the lower sideband. It is most noticeable on the 3.58 MHz color and 4.5 MHz sound sub-carriers. An acceptable upper limit for amateur service VUSB-TV is to keep the lower sideband SSC at least 20dB below the upper sideband SSC. This is usually found by driving the sync pulse tips up to, but not beyond the -1dB gain compression point of the amplifier. A good, linear amplifier should have a straight line on it's Pout vs. Pin plot and then smoothly roll-over at the top as it reaches saturation. RF amplifiers are typically rated for power output when this gain curve compresses by -1dB.

For linear amplifiers, we can not use class C. They must be either class A or class A-B. Thus an ATV amplifier will be much less efficient than a class C amplifier. Earlier amplifiers used bi-polar transistors. Linear amplifiers for TV service and in particular DTV service today mainly use MOSFET transistors.

TV transmitters output power ratings are different depending upon the modulation mode used. For an FM-TV transmitter, it's output is constant and the amplifier is driven to it's max. saturated output. The FM transmitter is thus rated in terms of average, power. For an AM-TV, or VUSB-TV transmitter, it's average power output is variable and depends upon the gray level of the video signal being broadcast. It can vary by several dB. What is constant for this transmitter is the peak power of the TV sync pulses. Thus this transmitter is rated in terms of it peak power, i.e. PEP (Peak Envelope Power). This is the same as the rating on a SSB transmitter.

As a typical example showing what can be expected in terms of output power, the following lists what is possible with the KH6HTV Video, model 70-9B amplifier, Fig. 19. This amplifier uses MOSFET transistors. It's max. saturated output power for CW or FM service is 70 Watts. It's -1dB gain compression point is about 25 Watts. This is thus the PEP rating for VUSB-TV service.

Fig. 21 shows several other possible amplifiers.



Fig. 19 KH6HTV 70-9 Amplifier

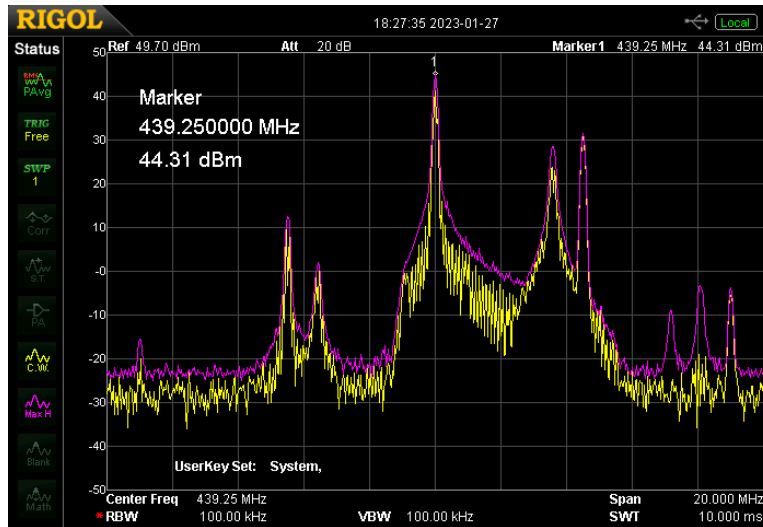


Fig. 20 Typical rf spectrum of a 70cm ATV, VUSB-TV transmitter. This is a 25 Watt transmitter consisting of a CATV modulator driving a KH6HTV Video model 70-9B amplifier. The rf drive level was set to bring the spurious SSC level on the lower side-band up to -20dB below the upper side-band SSC. The input video signal was a color bar test pattern. RF center frequency is Ch 60, 439.25 MHz. Vertical scale is 10dB/div. Horizontal scale is 2 MHz/div. Yellow trace is “live” single sweep. Magenta trace is analyzer in peak hold mode.



Fig. 21 Examples of other possible amplifiers to be used for 70cm AM-TV (left) Mirage D100, 100 Watt amp, (center) KH6HTV Video 70-7B, 10 Watt amp, (right) Chinese 3 Watt amp (note: 24Vdc)

## ANALOG TV RECEIVERS:



Fig. 22 Old TV receiver

As mentioned earlier, the first choice is obviously your home TV receiver. However, most modern TVs now only include a digital tuner and will not tune the older NTSC analog TV signals.

## CATV De-Modulators:

If you no longer own a suitable home TV receiver, then the ideal tuner (or De-Modulator) would be those used by the cable TV industry for their head-ends. These were made by the same companies mentioned earlier for the modulators. Fig. 23 shows one such de-modulator. It is in the mini-mod package and is identical in appearance to the modulators. A current (2026) search of the internet shows that most of these are now obsolete and no longer available. One exception found is the Toner company's model TAMD-860. It currently sells for \$171.



Fig. 23 CATV Demodulator

For writing this app. note, I did not have a Toner demodulator available. I instead used a similar mini-mod, Blonder-Tongue model MIDM-806C. Very similar in design and performance specs. Fully synthesized to cover all broadcast and cable TV channels. Adjustable A/V level controls. I measured it's rf sensitivity. Using modern video monitors, it is no longer possible to see very weak TV signals displayed. Most monitors today include a video squelch circuit which prohibits display of weak, snowy pictures. The squelch can not be disabled. For the video monitor I used for the tests, it's squelch was set for P2 picture level. For the B-T demodulator I found it's P2 level sensitivity was -94dBm. It's P level vs. rf input curve followed the one shown in previous Fig. 10. P5 was -64dBm.

## NTSC Analog TV Tuner:

Fortunately, there are available, low cost, set-top box receivers for NTSC. These function in the same manner as the set-top boxes supplied by the cable TV companies, satellite TV, etc. Simply connect the suitable antenna to the antenna port. The A/V output is then HDMI and / or RCA composite video plus stereo audio. The A/V output is then connected to a separate video monitor.



Fig. 24 NTSC Analog TV Tuner

Fig. 24 shows one such NTSC analog TV tuner (or de-modulator). A google search of the internet will find several possibilities. I recently purchased the one shown here for evaluation from Amazon for \$65. The only ID on it was a model number of RFDM3. No brand name. Made in China.

The tuner is quite small at 4"x2.5"x1" in a plastic case. Actually smaller than it's remote control. RF antenna input is a PAL connector, but a PAL to F adapter was included. A/V outputs are RCA for composite video, plus line level stereo audio. It is powered by a +5Vdc included wall wart. The included remote control is required for programming and all operations. It is a universal tv tuner design which supports rf frequencies for all NTSC and PAL systems.

One of these was purchased (2026) for evaluation. It was found to work to receive NTSC, AM-TV or VUSB-TV signals on the amateur 70cm band on cable channels 57-61. No controls on the unit. It is controled completely via the supplied remote control. I found it difficult to use. Even though there are numeric buttons on the remote control, it is not direct access. i.e. you can not simply enter either a channel number, nor a frequency by the remote control for channel selection. It has to be "scanned", like modern digital tv receivers. Once scanned it stores memorized channels. Not easy to use !

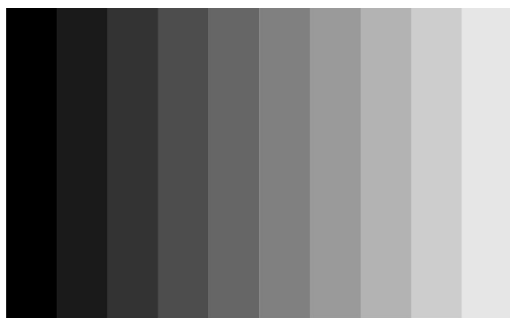
I measured it's rf sensitivity and compared it to the B-T demodulator. It was not as sensitive because it had a built-in video squelch. It stopped working at a P3 level of -88dBm. I tried adding a low noise preamp to it. With a pre-amp, I got a P3 picture at -91dBm, 3dB improvement.

I used the Toner VUSB-TV modulator as my "standard" for testing. It's SSC deviation was set to the industry standard of 25 kHz. I tested the video output of the receiver. It was quite "hot" with the 1.7 V ptp video into 75  $\Omega$ , vs. the standard of 1 V ptp. The level is not adjustable. In the absence of a valid input rf tv signal, the video output is a tv signal with a black screen and a white memory number displayed. I also tested it's audio performance. Using an 800 mV ptp, 1 kHz test tone, the test tuner put out a max. of

400 mV ptp. The volume level was adjustable via the remote control. The frequency response was quite flat with -3dB band-width extending from 63 Hz to 16 kHz.

## ATV REPEATERS:

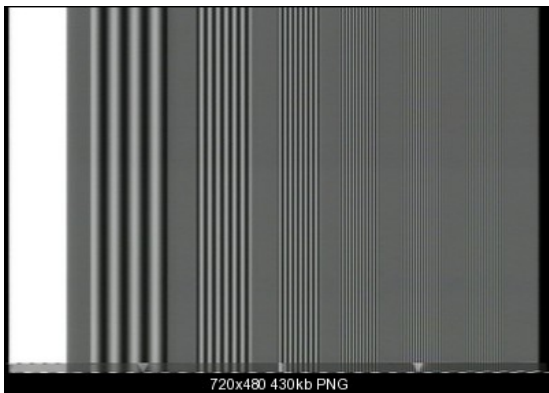
Radio amateurs have been building and using repeaters since at least the 1970s for NTSC analog TV. The principles of building a TV repeater is much the same as for a voice repeater. As shown in the previous Fig. 11, the ARRL band plan for the amateur 70cm band designates using channel 60 (439.25 MHz) as a TV repeater input and channel 57 (421.25 MHz) as the output. Most analog 70cm ATV repeaters in the US adhere to this plan. [7] Voice repeaters typically use a single antenna with a duplexer. Whereas for TV repeaters, we typically use two separate antennas for receive and transmit. Plus, separate, wide 6 MHz, sharp cut-off band-pass filters on the receiver and transmitter. A "Valid Signal" detector is required to key up a repeater. For voice repeaters, it is typically looking at the audio squelch line and/or listening for a DTMF (touch-tone) signal. For an analog TV repeater, we look for the presence of horizontal sync pulses. These occur at a 15 kHz rate. A simple 555 tone decoder is typically used.



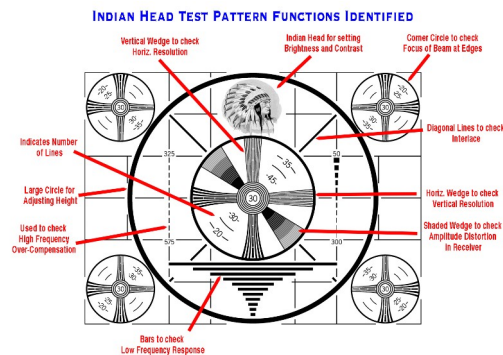
Gray Scale - Stair Case  
black to white



Color Bars



Multi-Burst



Indian Head

Fig. 25 NTSC TV Test Patterns

**TV TEST PATTERNS:** TV engineers and technicians have found using standardized test patterns useful for testing and alignment of TV systems. Here are a

few of the older test patterns used for analog TV, Fig. 25. A google search on the internet will come up with a lot more test patterns.

The most useful for aligning a simple ATV, AM-TV or VUSB-TV transmitter is the **Gray Scale** test pattern. It includes both solid black and solid white levels to set properly the modulation depth. It also includes a staircase of equal level steps with different shades of gray, useful for looking at the linearity.

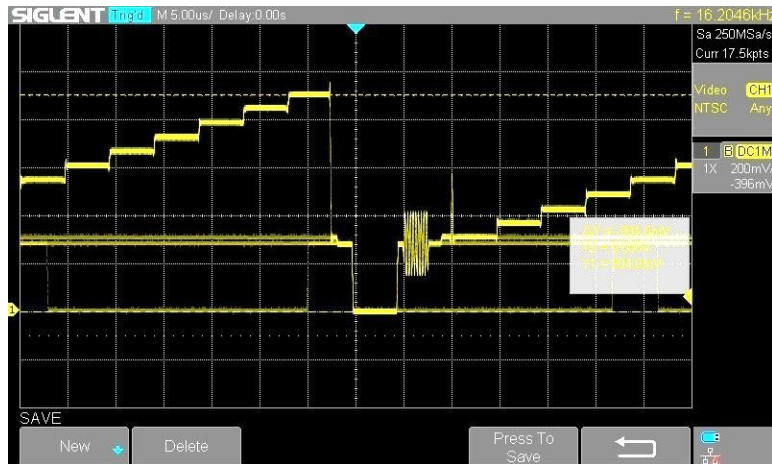


Fig. 26 Gray Scale Test Pattern waveform as measured on an oscilloscope. One horizontal line is shown.  $5\mu\text{s}/\text{div}$ . The horizontal sync pulse followed by the 3.58 MHz color burst is seen in the center.

The **Color Bars** test pattern also include both white and black levels, plus intermediate step levels with the different colors. Useful for determining color purity. Also great to use for your ham TV station ID by super-imposing your call sign over the color bars.



Fig. 27 Station ID

The **Multi-Burst** test pattern is useful as a quick check of frequency response. It starts with a step up to solid white. It is then followed by separated short bursts of rf sine waves of equal amplitude and increasing frequencies, centered at the 50 IRE level. They are: 0.5, 1.0, 2.0, 3.0, 3.58 & 4.2 MHz

The **Indian Head** test pattern is of mostly historical interest. It contained a wealth of test patterns in it. It's primary use was in the old vacuum tube, CRT receiver days when the service tech needed to make major adjustments in the focus, astigmatism and geometry of the CRT display tube.

**TV TEST EQUIPMENT:** There are several pieces of ham shack test equipment useful for testing and aligning your analog ATV gear. They obviously include a video camera and a video monitor as a bare minimum. Other items include: an oscilloscope, audio signal generator, rf signal generator, spectrum analyzer, rf power meter, etc. In the past, well equipped TV shops also included from Tektronix a TV waveform monitor, a vector signal analyzer, and a video waveform generator. Your oscilloscope can function well as the waveform monitor.

There are several low cost solutions to making a video test signal generator. Several video accessories such as an HDMI video splitter, etc. now create a color bar signal whenever they detect no valid incoming video signal. A very useful, low cost (\$40) device for the shack is what is called a "Media Player". It reads from a USB memory stick either picture (jpeg, etc) or video (mpg, etc) files and plays them automatically. It has both HDMI and composite video outputs. To create a stationary test pattern, copy onto your USB memory stick only one single picture file, such as those shown above in Fig. 25.

Fig. 28 shows my NTSC waveform test generator. The blue module is the Media Player. I found that it's composite video signal output was quite low (0.3V ptp) and did not meet the standard of 1.0V ptp.



Fig. 28 NTSC Test Pattern  
Waveform Generator

I thus took the HDMI output from the media player and ran it to the black module, which is an HDMI to composite video converter. It gave me almost the correct level composite video which is being displayed on the video monitor.

Your TV camera can also be used as an alignment tool. Set it up on a fixed tripod looking at a fixed scene. The scene could in fact be a well lighted paper TV test pattern. The scene should have some very bright white features along with some extremely black features in it. You should then use your oscilloscope to test your camera's video output to verify that it is putting out standard 1.0 V ptp video into a 75  $\Omega$  load. If it's output is too "hot", i.e. too high, it is best to make a simple attenuator to pull it down to the standard 1.0 V level. However, if the camera is the only source of video you plan to use with your TV transmitter, then you should instead use it as the primary alignment tool for setting your transmitter's AM modulation depth.

## AM-TV Transmitter Alignment:

For proper, optimum performance, the audio and video levels and rf drive levels in your TV transmitter need to be properly aligned. If the rf drive level is too high, the sync tips will be clipped and receivers will not lock onto your transmissions. If your video levels are too low, your video will be dim and washed out. If video levels are too high, they will interfere with the sound and create sync buzzing in the audio. If your audio level is too high, it will over deviate the FM sound sub-carrier and create audio distortion.

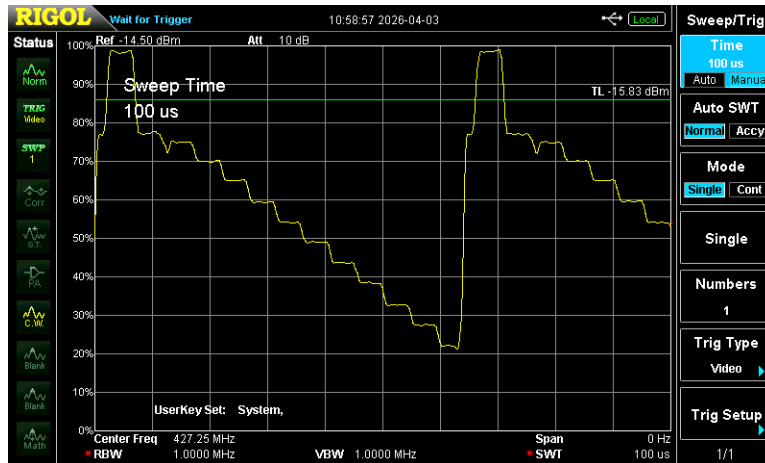


Fig. 29 Measurement of video signal modulation depth, using a gray scale staircase test signal.

**Modulation Depth:** The best method to properly set the modulation depth of an AM-TV transmitter is to use the gray scale, staircase test signal along with a good quality spectrum analyzer. The signal signal should be the standard level of 1.0 V (75  $\Omega$ ). (note: for the example above, my particular test signal was not 1.0 V, but instead it was 0.9V ). The modulation depth is adjusted using the Video Gain control on the modulator. For the above Fig. 29 example, a Rigol model DSA-815, 1.5 GHz spectrum analyzer was used.

The spectrum analyzer should be set up as follows:

1. First look at the overall spectrum. It should appear similar to either Fig. 7 or 8.
2. Set the analyzer center frequency to the video carrier frequency.
3. Set the detector type to "normal"
3. Set the SA's resolution and video band-widths to the max. possible. For the Rigol this was 1 MHz.
4. Adjust the ref. amplitude level to position the displayed spectrum to the top line of the display.
5. Change the display type from "log" to "linear". note: the top line of the display is now 100% while the bottom line of the display is 0%.
6. With the display free-running you will not see a stationary display yet.
7. Increase the sweep speed to 100  $\mu$ s

8. Change the trigger mode from normal to "Video"
9. This now gives you an adjustable trigger level control. Set the trigger level to 90%.
10. Hopefully, you will now see a display similar to that shown in the above Fig. 29.
11. Fine tune the reference level to set the top of the sync pulse exactly to the 100 %, top line.

Now adjust the video gain control to set the proper levels. See the FCC standard spec. shown earlier in Fig. 4. IF you are using an ideal, perfect 1.0 V test signal, then the blanking level of the sync pulse will be at 75%. The peak white level will be at +12.5%. This is defined as 87.5% modulation.

Note: With typical ham AM-TV transmitters which also include a 4.5 MHz FM audio sound sub-carrier mixed in with the video signal, we have found that it is best to not push the white level all the way down to the FCC spec. of 12.5%. Something in the order of 15 to 20% is better. Pushing the white level too low, along with a strong SSC will actually cause the total AM modulation to drive all the way down to 0% cut-off and create objectionable "buzzing" in the received audio signal.

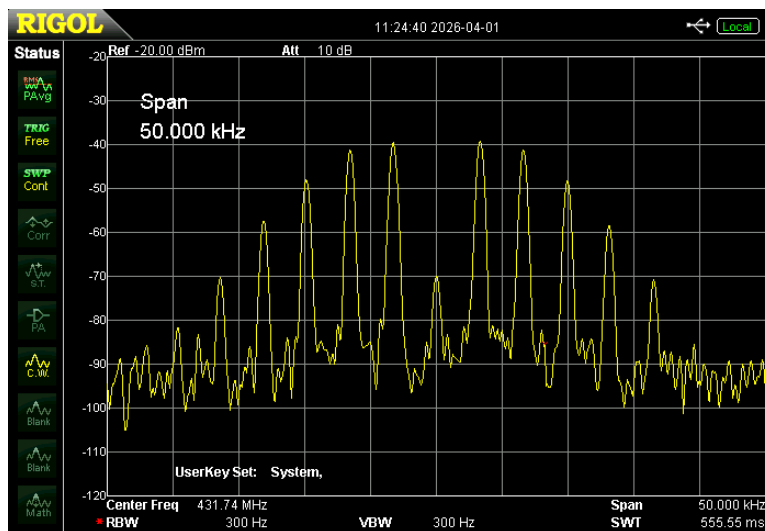


Fig. 30 Proper alignment of the SSC for 25 kHz deviation

**FM SSC Deviation:** Another adjustment to be made on your ham AM-TV transmitter's modulator is the audio gain level. This controls the deviation of the 4.5 MHz sound sub-carrier. I recommend at this point you read my app. note, AN-14, "FM Transmitter Deviation Adjustment & Calibration"[8] It discusses in detail this alignment procedure. AN-14 tells you the proper audio test tone to be used for the alignment. Use a spectrum analyzer to look at the rf SSC, see Fig. 30. FM causes a Bessel function in the frequency spectrum. Set the audio gain control to minimum. Then slowly increase the gain while watching the center frequency. When it nulls out, you have set the FM deviation to the proper 25 kHz setting.

**Final Amplifier Drive Level:** The final adjustment to be made to your AM-TV transmitter is the rf drive level to the final amplifier. We want to maximize the rf output power from the amplifier, but without over-driving it to distortion. The max. portion of the rf signal is the sync pulses. They drive the output to the 100% modulation level. If we push the rf drive too much, we drive the amplifier into saturation and thus clip off the peaks of these sync pulses. With weak sync pulses, TV receivers have difficulty locking onto the TV signal.

**VUSB-TV:** If you are using a VUSB-TV modulator, the procedure is quite simple. Use a spectrum analyzer to look at the overall spectrum of the transmitter's rf output with a span of 20 MHz. See Figs. 8 & 20. Fig. 8 shows an ideal VUSB-TV spectrum. Fig. 20 shows the typical output from a ham VUSB-TV transmitter. Start out with a low rf drive level while monitoring the -SSC on the lower side-band. As you start to increase the rf drive level you will see the height of this -SSC start to grow. Continue increasing the rf drive until the -SSC is set to be no more than -20dB below the level of the +SSC on the upper side-band. At this level, you still have a relatively pure VUSB signal and the sync pulses have been compressed only slightly by a couple of IRE units.

**AM-TV:** For an AM-TV transmitter, the measurement method is the same as used previously in setting up the modulation depth with the video gain level. See Fig. 29. Do not touch the video gain level control for this step. This time start with the rf drive level control set to minimum. Monitor in particular the shape of the displayed sync pulses. As you increase the rf drive level, you will eventually reach a point where the sync pulses start to compress in relative level to the rest of the stair step pattern. Normally the blanking level is at 75%. As the sync starts to compress you will note the blanking level rising. Stop when it reaches no higher than 80%. At this point you still have a 20% sync remaining.

**GET ON THE AIR !** This completes this application note. Now it is time for you to get on the air with AM-TV and share videos with your fellow ham ATV buddies.

## REFERENCES:

1. "ATV Handbook - an Introduction to Amateur TV", Jim Andrews, KH6HTV Video app. note AN-55b, rev. March, 2026, 40 pages
2. "Why VUSB-TV vs. AM-TV", Jim Andrews, KH6HTV Video app. note, AN-1, Sept. 2011, 3 pages
3. "P5 - TV Signal Quality Reporting", Jim Andrews, KH6HTV Video app. note, AN-5a, rev. Sept 2019, 3 pages
4. "70cm & Microwave Amateur TV Frequencies", Jim Andrews, KH6HTV Video app. note, AN-10c, rev. June 2022, 5 pages

5. "Replacement for Crystals - PXOs", Jim Andrews, KH6HTV Video app. note, AN-56a, May, 2020, 5 pages
6. "Inter-Digital Band-Pass Filters", Jim Andrews, KH6HTV Video app. note, AN-22b, July 2015, 8 pages
7. "USA ATV Repeater Directory", Jim Andrews, KH6HTV Video app. note, AN-74, March 2026, 3 pages
8. "FM Transmitter Deviation Adjustment & Calibration", Jim Andrews, KH6HTV Video app. note, AN-14, Aug. 2012, 4 pages